Improved Drying Rate Diagnostics For Saturated Fuel Debris At The INEEL

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Introduction

A Fuel Canning Station (FCS) has been operated for approximately 2 years to prepare for dry storage a variety of spent reactor fuels stored in pools at the INEEL. The FCS dewaters the fuel and then passivates possibly pyrophoric components in the fuel. Fuel-loaded canisters are placed into a heated insert, the canister is connected to a vacuum system, and the fuel is heated under a vacuum to remove the water. The dewatering system must also verify that the water was removed. The dryness criteria states that the canister pressure shall not exceed a defined pressure for a specified isolation time.

Dewatering did not work well for defected TRIGA elements that had corroded in pool storage, leaving the intact fuel meat mixed with a bed of fines from metal oxides and from sludge that continuously accumulated within the pool. This fuel was stored in open-topped cans provided with drain holes assumed to drip-drain all but a small amount of water that would be removed in the FCS. Cans were visually observed to be water-filled while being transferred into the FCS, indicating little or no drip-drainage prior to drying.

Dewatering these cans proved to be very time consuming. Fueled canisters were heated to 60 ^{0}C and evacuated between 5 and 10 torr. At these conditions, intact fuels were rapidly dried (less than 10 hours). TRIGA drying periods extended to 9 days. Dryness was qualitatively monitored using the canister pressure-control valve position. The valve closes as the gas flow rate declines, providing an indication that drying is complete. However, the valve remained open when drying TRIGA fuel, leaving no indication of dryness. In addition, dryness could not be verified because the canister pressure exceeded the defined pressure during isolation.

Air leakage into the evacuated canister prevented the dryness from being verified. Air in-leakage and water vapor cannot easily be discriminated by the procedures described above. Since the canister design does not seal above atmospheric pressure, a drying temperature that yielded a vapor pressure less than atmospheric pressure was chosen. A sufficiently long isolation test could then determine if air was accumulating in the canister; however, the low temperature reduced the drying rate unacceptably. This paper answers two questions: 1) at a higher drying temperature, can fuel be verified dry in the presence of air leaks? And 2) Can an indicator of drying progress be developed?

Description of Work

A series of isolation tests were performed while dewatering TRIGA fuel in the FCS. Isolation test pressurization rates plotted with drying time are shown in Figure 1. This figure was used to predict dewatering progress.

Results

Figure 1 provides a simple method for discriminating between pressure increases from water vaporization and from air leakage. Air in-leakage and water vapor produce the minimum and varying portions of the pressure increase, respectively. Being able to identify and quantify the air leakage permits dewatering and dryness verification to proceed without having to identify and eliminate the leak first.

Figure 1 also provides an indication of drying progress, and may be used to estimate the remaining time needed to completely dry the fuel. The declining vaporization rates resulted from drying a bed of water-saturated solids. Solids drying is characterized by initially rapid ("constant rate") vaporization until the water content declines below a "critical" value. After this the vaporization rate declines proportional to the water content. Because isolation pressure increases are proportional to the rate of water removal, the falling rate solids drying relationship was used to predict the remaining dewatering time from the isolation pressure increases. The estimate was updated whenever a new isolation was performed. The results shown in Figure 2 indicate that remaining dewatering time may be predicted quite accurately from these tests. For these reasons, periodic isolations and vaporization rate trending has been automated and is now used to control operation of the INEEL FCS.

Figure 1. Isolation pressure increases during TRIGA 3 dewatering in the FCS

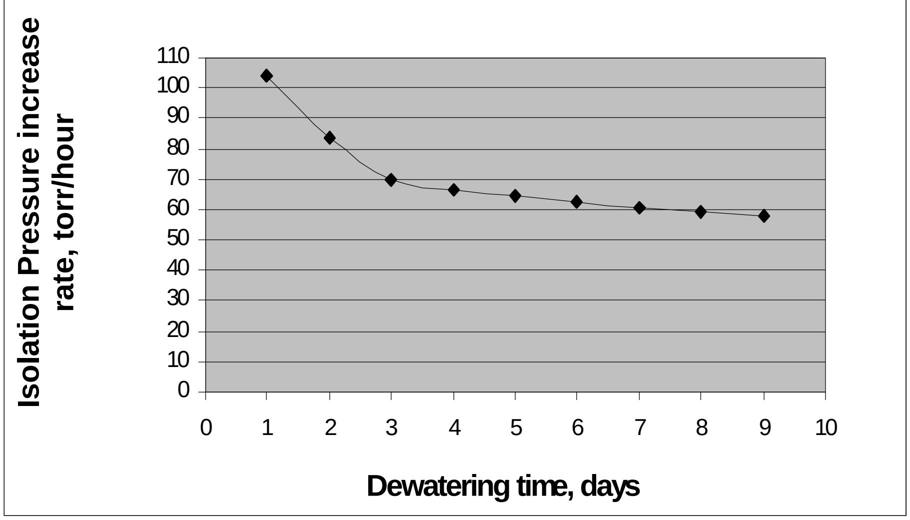

Figure 2. Comparison of actual with estimated remaining drying time